ZooKeys 1196: 285–301 (2024)
DOI: 10.3897/zookeys.1196.109810

Research Article

A new loach species of the genus *Oreonectes* (Teleostei, Cypriniformes, Nemacheilidae) from Guangxi, China

Xue-Ming Luo[1,2], Rui-Gang Yang[3], Li-Na Du[1,2], Fu-Guang Luo[4]

1 *Key Laboratory of Ecology of Rare and Endangered Species and Environmental Protection (Guangxi Normal University), Ministry of Education Guilin 541004, China*
2 *Guangxi Key Laboratory of Rare and Endangered Animal Ecology, College of Life Science, Guangxi Normal University, Guilin 541004, China*
3 *Scientific Research Academy of Guangxi Environmental Protection, Nanning, Guangxi 530022, China*
4 *Liuzhou Aquaculture Technology Extending Station, Liuzhou 545006, China*

Corresponding authors: Li-Na Du (dulina@mailbox.gxnu.edu.cn); Fu-Guang Luo (luofuguang3563@163.com)

Abstract

A new loach species, *Oreonectes andongensis* **sp. nov.** is described from the Guangxi Zhuang Autonomous Region, China. The new species can be differentiated from other members of the genus by combinations of characters: a developed posterior chamber of the swim bladder, 13–14 branched caudal-fin rays, 8–16 lateral-line pores, body width 12–15% of standard length (SL), interorbital width 42–47% of head length (HL), and caudal peduncle length 11–16% of SL. Bayesian inference phylogenetic analysis based on mitochondrial Cyt *b* provided strong support for validity of *O. andongensis* **sp. nov.** (uncorrected *p*-distance 6.0–7.5%).

Key words: New species, morphology, phylogeny, taxonomy, Xijiang River

OPEN ACCESS

Academic editor: Nina Bogutskaya
Received: 20 July 2023
Accepted: 12 February 2024
Published: 28 March 2024

ZooBank: https://zoobank.org/3218C5F9-C9A4-4A57-BB82-67800B9F48F3

Citation: Luo X-M, Yang R-G, Du L-N, Luo F-G (2024) A new loach species of the genus *Oreonectes* (Teleostei, Cypriniformes, Nemacheilidae) from Guangxi, China. ZooKeys 1196: 285–301. https://doi.org/10.3897/zookeys.1196.109810

Copyright: © Xue-Ming Luo et al.
This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0).

Introduction

The freshwater fish genus *Oreonectes* Günther, 1868, which belongs to the family Nemacheilidae, exhibits notable adaptations to the karst geomorphic environment. These small fish are predominantly distributed in southern China (Xijiang River system of Guangxi Zhuang Autonomous Region, Pearl River system of Guangdong Province, and Pearl River system of Hong Kong) and Kalong River of northern Vietnam (Quảng Ninh Province in northeast Vietnam) (Kottelat 2012). The genus was first established by Günther in 1868, designating *Oreonectes platycephalus* Günther, 1868 as the type species, collected from a small stream in Hong Kong within the Pearl River system. The diagnosis of the genus included a slightly compresses body, a markedly depressed head, and the origin of the dorsal fin much closer to the base of the caudal fin than to the operculum Günther (1868). Later, till 2006 a number of species have been added to the genus: *O. anophthalmus* Zheng, 1981 (an underground river in Taiji Cave, Wuming County, Guangxi, Youjiang River, China), *O. furcocaudalis* Zhu & Cao, 1987 (a subterranean water outlet in the suburbs of Rongshui County, Guangxi, Liujiang River, China), *O. retrodorsalis* Lan, Yang & Chen, 1995 (an underground river outlet in Longli Village, Nandan County, Guangxi, Hongshui River, China), and *O. translucens* Zhang, Zhao & Zhang, 2006 (Xia'ao

Town, Du'an County, Guangxi, Hongshui River, China) (Zheng 1981; Zhu 1989; Lan et al. 1995; Zhang et al. 2006). Subsequently, a revision of *Oreonectes* was published with description of two new species *O. microphthalmus* Du, Chen & Yang, 2008 (Du'an County, Guangxi, Hongshui River, China) and *O. polystigmus* Du, Chen & Yang, 2008 (Dabu Village, Guilin City, Guangxi, Lijiang River, China) (Du et al. 2008). Meanwhile, Du et al. (2008) subdivided the genus into two groups based on the caudal fin morphology: the round caudal fin group (*O. platycephalus* group), containing *O. anophthalmus*, *O. platycephalus*, *O. polystigmus*, and *O. retrodorsalis*, and the forked caudal fin group (*O. furcocaudalis* group), including *O. furcocaudalis* and *O. microphthalmus*. After 2009, various species were described, including *O. macrolepis* Huang, Du, Chen & Yang, 2009 (an underground river in Dacai Town, Huanjiang County, Guangxi, Xijiang River system, China), *O. luochengensis* Yang, Wu, Wei & Yang, 2011 (a cave near Tianhe Town, Luocheng County, Guangxi, Xijiang River system, China), *O. guananensis* Yang, Wei, Lan & Yang, 2011 (an underground karst cave outlet near Guan'an Village, Changmei Town, Huanjiang County, Guangxi, Xijiang River system, China), *O. elongatus* Tang, Zhao & Zhang, 2012 (Mulun Town, Huanjiang County, Guangxi, Longjiang River, China), *O. acridorsalis* Lan, 2013 (a cave near Bamu Town, Tian'e County, Guangxi, Hongshui River, China), *O. barbatus* Gan, 2013 (first described from a cave near Lihu Town, Nandan County, Guangxi, Hongshui River, China), *O. donglanensis* Wu, 2013 (a cave near Simeng Town, Donglan County, Guangxi, Hongshui River, China), *O. duanensis* Lan, 2013 (a cave near Chengjiang Town, Du'an County, Guangxi, Hongshui River, China), *O. daqikongensis* Deng, Xiao, Hou & Zhou, 2016 (Seven Big Scenic Spot, Libo County, Guizhou, Hongshui River, China), *O. shuilongensis* Deng, Wen, Xiao & Zhou, 2016 (a cave near Shuilong Town, Sandu County, Guizhou, Duliu River, China), *O. guilinensis* Huang, Yang, Wu & Zhao, 2020 (Shigumen Village, Xingping Town, Yangshuo County, Guilin City, Guangxi, Lijiang River, China), and *O. damingshanensis* Yu, Luo, Lan, Xiao & Zhou, 2023 (Wamenggu Scenic Area, Leping Village, Guling Town, Mashan County, Guangxi, Xijiang River system, China) (Huang et al. 2009, 2020; Yang et al. 2011a, b; Tang et al. 2012; Lan et al. 2013; Deng et al. 2016a, b; Yu et al. 2023). Zhang et al. (2016) established the genus *Troglonectes* Zhang, Zhao & Tang, 2016, designating *O. furcocaudalis* as the type species, with *O. barbatus*, *O. elongatus*, *O. macrolepis*, *O. microphthalmus*, and *O. translucens*, characterized by a forked caudal fin, a developed adipose crest of the caudal fin, and the dorsal-fin origin above the pelvic-fin origin. Later studies added *O. daqikongensis*, *O. donglanensis*, *O. duanensis*, *O. retrodorsalis*, and *O. shuilongensis* to *Troglonectes* (Huang et al. 2020; Du et al. 2023), while *O. anophthalmus* and *O. acridorsalis* were assigned to a new genus, *Karstsinnectes* Zhou, Luo, Wang, Zhou & Xiao, 2023 based on morphological and molecular evidence (Luo et al. 2023).

Until now, the genus of *Oreonectes* contains six valid species, namely, *O. damingshanensis*, *O. guananensis*, *O. guilinensis*, *O. luochengensis*. *O. platycephalus*, and *O. polystigmus*. In July 2022, ten loach specimens were collected from Laibin City in the Hongshui River system, Guangxi Zhuang Autonomous Region, China. Morphological features and molecular data suggest that the specimens under consideration represent a previously undescribed species within the genus *Oreonectes*, which are described herein.

Materials and methods

Field collections followed the Guide to Collection, Preservation, Identification, and Information Share of Animal Specimens (Xue 2010) and Implementation Rules of Fisheries Law of the People's Republic of China. All activities followed the Laboratory Animal Guidelines for the Ethical Review of Animal Welfare (GB/T 35892–2018). Specimens of the new species were collected by FGL. Samples were collected using a hand net and mesh traps. Freshly caught fish were euthanized using eugenol. After death, the pectoral fins from the right side were taken and preserved in ethanol for molecular analysis. Specimens used for morphological studies were preserved in 10% formalin, before being transferred to 75% ethanol for long-term storage at the collection of the Key Laboratory of Ecology of Rare and Endangered Species and Environmental Protection (Guangxi Normal University), Ministry of Education.

Phylogenetic analyses

Mitochondrial cytochrome *b* gene (Cyt *b*) sequences were sequenced by the Science Corporation of Gene (China) following standard Illumina protocols. Genome sequencing data were submitted to GenBank (Accession No. OR188128, OR712240, OR712241). We retrieved 36 Cyt *b* sequences of Nemacheilidae species from the NCBI GenBank database (Appendix 1) for phylogenetic tree reconstruction to test the phylogenetic positions of *Oreonectes andongensis* sp. nov. All sequences were aligned in MEGA v. 11.0 (Tamura et al. 2021) by the MUSCLE (Edgar 2004) algorithm with default parameters, and then sequences were executed in PartitionFinder v. 2.1.1 (Lanfear et al. 2017) in order to select the most appropriate model of evolution to be used for phylogenetic analyses. The model selection for each codon position of the complete mitochondrial genes indicated that the best fit models were K80+I+G for the first codon, HKY+I+G for the second codon, and TRN+I+G for the third codon. Bayesian inference (BI) analysis was performed using MRBAYES v. 3.2.6 (Ronquist et al. 2012). The chains were run for two million generations and sampled every 1000 generations. The first 25% of the sampled tree was discarded as burn-in, and the remaining trees were used to create a consensus tree and to estimate Bayesian posterior probabilities (BPP). Nodes in the trees were considered well-supported at BPP ≥ 0.95.

Morphological examination

Methods used for counts and measurements followed Du et al. (2021) and characteristics of the cephalic lateral line system were examined following Kottelat (1990) and Tang et al. (2012). All measurements were taken point-to-point with dial calipers to the nearest 0.1 mm. Abbreviations used in the text are as follows: **AFBL** for anal-fin base length, **AFL** for anal-fin length, **BD** for body depth, BW for body width, **CPL** for caudal peduncle length, **CPD** for caudal peduncle depth, **DAPN** for distance between anterior and posterior nostrils, **DAN** for distance between anterior nostrils, **DFBL** for dorsal-fin base length, **DFL** for dorsal-fin length, **DPN** for distance between posterior nostrils, **ED** for

eye diameter, **HD** for head depth, **HL** for head length, **HW** for head width, **ISBL** for inrostral barbel length, **IW** for interorbital width, **MBL** for maxillary barbel length, **OSBL** for outrostral barbel length, **PANL** for preanus length, **PAL** for pre-anal length, **PDL** for predorsal length, **PFBL** for pectoral-fin base length, **PFL** for pectoral-fin length, **PPL** for prepectoral length, **PVL** for prepelvic length, **STL** for snout length, **SL** for standard length, **TL** for total length, **VFBL** for pelvic-fin base length, and **VFL** for pelvic-fin length.

Results

Genetic evidence from phylogenetic analysis

BI analyses were performed to construct a phylogenetic tree, revealing consistent topologies based on Cyt *b* sequences spanning 1141 bp. The phylogenetic tree affirmed the validity of the new species with high nodal support (BPP ≥ 0.95). Additionally, members of the Oreonectes genus constituted a monophyletic group, which was phylogenetically sister to the *Guinemachilus* Du et al., 2023 and *Micronemacheilus* clade (Fig. 1). *Oreonectes andongensis* sp. nov. formed a highly supported clade with *O. damingshanensis*, *O. guilinensis*, *O. platycephalus*, and *O. polystigmus*.

The uncorrected *p*-distances of Cyt *b* between *Oreonectes andongensis* sp. nov. and the other six species ranged from 6.0% (for *O. polystigmus*) to 7.5% (for *O. guananensis*) (Table 2).

Taxonomy

***Oreonectes andongensis* Luo, Yang, Du & Luo, sp. nov.**
https://zoobank.org/31E2362E-71AF-4E1F-B78A-53DFB1980F33
Table 1, Figs 1–5

Type material. ***Holotype*.** GXNU20220601, 74.9 mm standard length (SL), Andong Town, Xincheng County, Laibin City, Hongshui River system, Guangxi Zhuang Autonomous Region, China, 24°18.57'N, 108°59.61'E, 179 m a.s.l., collected by F.G.L., 20 July 2022. ***Paratypes*.** GXNU20220602–10, 9 specimens, 45.9–68.7 mm SL, same data as holotype.

Diagnosis. The new species is assigned to the genus *Oreonectes* based on Cyt *b* phylogenetic analysis and morphological characters. The new species can be distinguished from other members of *Oreonectes* by the following combination of characters: posterior chamber of swim bladder developed (vs reduced in *O. platycephalus*), color pattern present (vs colorless in *O. luochengensis*), tip of pelvic fin not reaching anus (vs exceeding anus in *O. polystigmus* and *O. guilinensis*), dorsal-fin origin slightly posterior to pelvic-fin origin (vs opposite in *O. guananensis*), six branched pelvic-fin rays (vs 7 or 8 in *O. damingshanensis*, *O. guananensis*, *O. luochengensis*). *Oreonectes andongensis* sp. nov. can be further differentiated from *O. damingshanensis* by more numerous, better developed inner gill rakers on the first gill arch (11–12 vs 9).

Description. The morphometric data of the holotype and paratypes are in Table 1. Three unbranched and seven branched dorsal-fin rays, one unbranched and nine or ten branched pectoral-fin rays, one unbranched and six

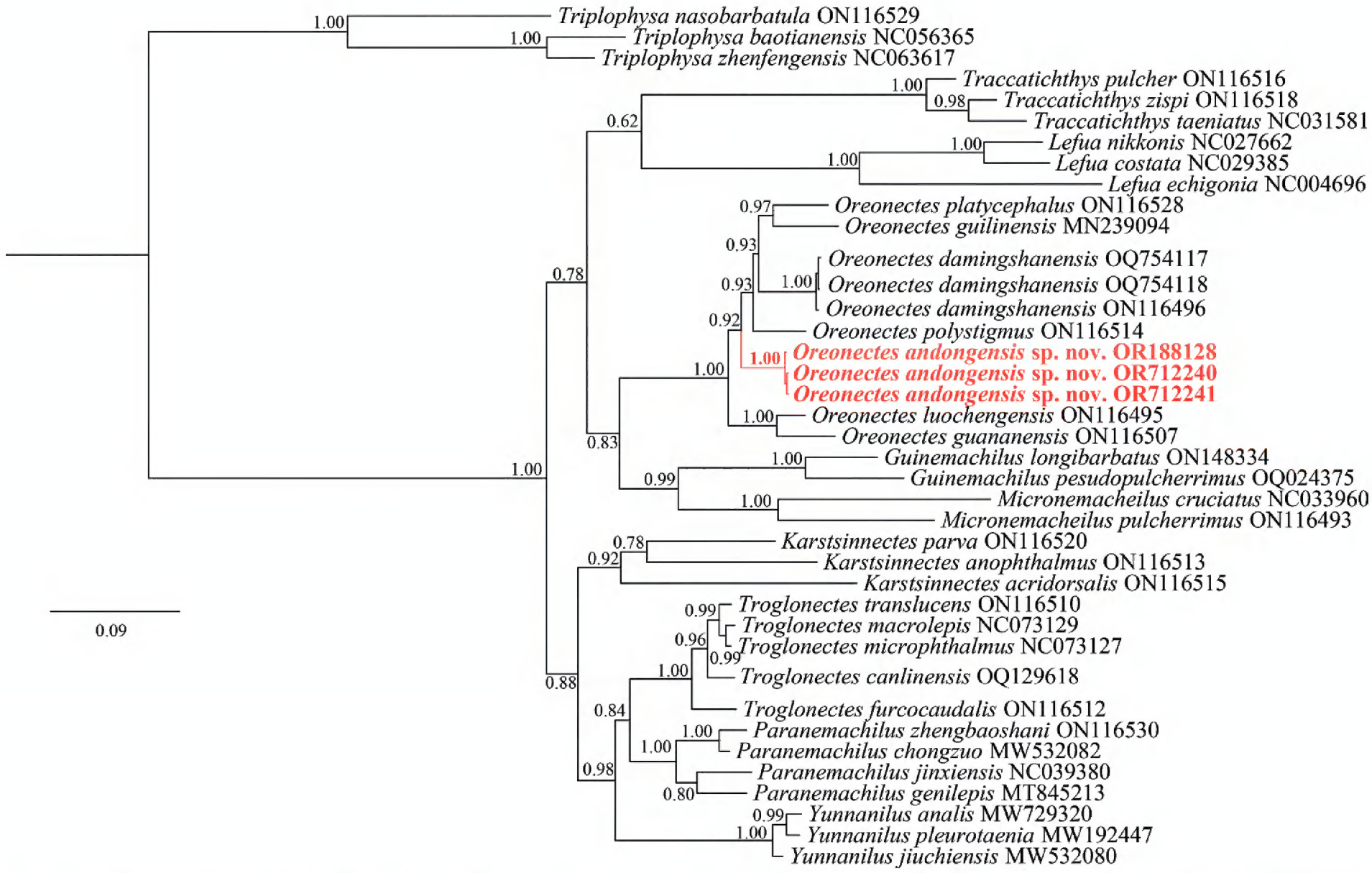

Figure 1. Bayesian phylogenetic tree of *Oreonectes* based on mitochondrial Cyt *b*. Numbers above branches are BPPs.

Table 1. Morphological data and habitat types of the genus *Oreonectes*. Data of *O. damingshanensis* is from the original description (Yu et al. 2023).

	***O. andongensis* sp. nov.**	***O. damingshanensis***	***O. guananensis***	***O. guilinensis***	***O. luochengensis***	***O. platycephalus***	***O. polystigmus***
	Range (Mean ± SD)	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**
TL (mm)	45.9–74.9 (57.1 ± 9.9)	63.7–98.9 (78.8 ± 8.8)	62.9–90.2 (75.7 ± 10.5)	63.2–89.7 (80.4 ± 7.6)	77.2–92.1 (84.2 ± 4.8)	49.6–82.5 (65.2 ± 11.7)	41.8–67.8 (52.2 ± 8.0)
SL (mm)	36.5–60.2 (46.2 ± 8.4)	52.5–81.8 (64.9 ± 7.3)	51.0–71.5 (60.9 ± 8.3)	52.0–73.5 (65.9 ± 6.1)	62.2–74.7 (68.1 ± 4.3)	38.7–64.2 (51.2 ± 9.3)	33.7–54.7 (42.5 ± 6.7)
Percentage of SL (%)							
BD	15.7–17.9 (16.7 ± 0.7)	14.2–18.1 (15.5 ± 1.3)	16.2–19.6 (17.6 ± 1.3)	16.7–18.5 (18.0 ± 0.5)	16.0–18.3 (17.3 ± 0.7)	14.8–19.3 (17.2 ± 1.4)	12.5–19.5 (16.3 ± 2.2)
BW	11.5–15.2 (12.7 ± 1.0)	10.4–12.5 (11.3 ± 0.6)	9.5–13.1 (11.3 ± 1.3)	12.7–14.8 (13.9 ± 0.6)	9.8–12.1 (10.8 ± 0.8)	9.5–11.5 (10.5 ± 0.5)	7.4–11.8 (8.7 ± 1.2)
HW	14.7–17.2 (15.7 ± 0.7)	14.4–17.8 (16.1 ± 1.0)	14.8–16.9 (15.9 ± 0.7)	15.4–19.0 (17.0 ± 1.1)	13.7–16.9 (14.9 ± 0.9)	14.6–17.5 (15.7 ± 0.8)	13.7–17.5 (15.5 ± 1.2)
HD	11.4–12.8 (12.1 ± 0.5)	10.8–12.9 (12.0 ± 0.7)	10.9–11.9 (11.4 ± 0.4)	12.0–15.2 (13.3 ± 1.0)	10.0–12.4 (11.1 ± 0.7)	10.3–13.5 (11.3 ± 0.9)	11.1–13.1 (12.1 ± 0.7)
HL	21.1–24.5 (22.3 ± 0.9)	20.2–23.0 (21.7 ± 0.9)	21.8–23.2 (22.6 ± 0.5)	20.3–24.2 (21.7 ± 1.1)	20.7–24.2 (22.4 ± 1.0)	20.8–25.4 (22.8 ± 1.4)	22.3–24.5 (23.6 ± 0.6)
PDL	57.7–62.4 (60.0 ± 1.7)	59.5–62.4 (60.7 ± 0.8)	57.2–59.5 (58.4 ± 0.8)	57.4–60.4 (58.9 ± 0.9)	58.0–63.3 (60.0 ± 1.5)	60.0–64.7 (62.0 ± 1.9)	59.2–63.9 (60.9 ± 1.6)
DFL	16.8–19.2 (18.1 ± 0.7)	17.2–21.7 (18.9 ± 1.2)	17.6–18.6 (18.0 ± 0.3)	16.6–19.0 (17.4 ± 0.8)	16.9–19.2 (18.2 ± 0.7)	15.7–21.1 (19.4 ± 1.6)	16.8–19.8 (18.1 ± 1.0)
DFBL	8.9–11.6 (10.4 ± 0.8)	9.0–11.3 (10.3 ± 0.7)	9.5–11.0 (10.1 ± 0.6)	7.2–10.4 (8.8 ± 0.9)	6.6–7.3 (7.0 ± 0.3)	9.4–11.1 (10.1 ± 0.5)	8.9–12.1 (10.0 ± 1.0)
PPL	19.4–23.7 (21.2 ± 1.2)	19.1–22.7 (21.4 ± 1.0)	21.4–23.0 (22.0 ± 0.5)	16.9–20.4 (19.1 ± 1.2)	19.0–21.8 (20.3 ± 0.7)	18.1–22.4 (21.1 ± 1.6)	19.2–25.2 (22.0 ± 1.6)
PFL	15.1–18.9 (16.7 ± 1.0)	15.5–18.7 (16.9 ± 1.1)	14.5–17.1 (16.1 ± 0.9)	14.2–16.0 (15.3 ± 0.6)	15.3–18.5 (17.1 ± 1.0)	15.1–22.1 (19.3 ± 1.8)	13.5–19.4 (15.6 ± 1.7)

	***O. andongensis* sp. nov.**	***O. damingshanensis***	***O. guananensis***	***O. guilinensis***	***O. luochengensis***	***O. platycephalus***	***O. polystigmus***
	Range (Mean ± SD)	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**	**Range (Mean ± SD)**
PFBL	3.2–4.3 (3.9 ± 0.3)	3.6–4.5 (4.0 ± 0.3)	3.4–4.5 (3.9 ± 0.4)	3.1–4.5 (3.9 ± 0.5)	4.0–5.6 (4.6 ± 0.5)	3.9–5.2 (4.5 ± 0.6)	2.7–4.5 (3.9 ± 0.5)
PVL	54.3–58.2 (56.1 ± 1.4)	48.6–52.2 (50.6 ± 1.0)	55.4–57.4 (56.5 ± 0.9)	53.8–55.8 (55.1 ± 0.8)	55.3–60.3 (56.3 ± 2.1)	52.2–56.4 (54.4 ± 1.7)	53.4–57.1 (55.1 ± 1.2)
VFL	11.1–13.6 (12.5 ± 0.8)	14.7–17.2 (15.8 ± 0.9)	14.5–17.1 (16.1 ± 0.9)	10.9–12.5 (11.8 ± 0.6)	11.9–14.7 (13.4 ± 0.9)	15.5–22.1 (19.3 ± 1.8)	12.1–15.7 (13.6 ± 1.2)
VFBL	3.0–4.0 (3.5 ± 0.4)	3.2–4.3 (3.8 ± 0.3)	3.0–4.2 (3.6 ± 0.4)	2.6–3.5 (3.2 ± 0.3)	3.1–3.9 (3.3 ± 0.2)	3.8–5.4 (4.5 ± 0.6)	2.7–4.0 (3.2 ± 0.4)
PAL	78.6–82.6 (80.0 ± 1.1)	74.6–77.9 (75.6 ± 1.0)	77.3–81.6 (80.6 ± 1.5)	78.4–81.2 (79.6 ± 0.9)	80.1–83.0 (81.3 ± 1.0)	77.6–80.5 (79.1 ± 1.0)	76.7–81.7 (79.9 ± 1.4)
AFL	14.3–17.7 (15.7 ± 1.1)	16.1–18.1 (16.9 ± 0.6)	14.2–16.1 (15.0 ± 0.6)	14.3–15.6 (14.6 ± 0.6)	14.0–16.8 (15.6 ± 0.8)	14.4–19.2 (17.8 ± 1.5)	14.9–17.2 (16.1 ± 1.0)
AFBL	6.8–8.1 (7.4 ± 0.5)	7.3–9.4 (8.4 ± 0.6)	6.7–7.5 (7.1 ± 0.3)	5.9–7.6 (6.8 ± 0.5)	6.6–7.3 (7.0 ± 0.3)	7.5–9.0 (8.1 ± 0.5)	7.1–11.0 (8.4 ± 1.2)
PANL	72.2–77.4 (74.1 ± 1.6)	78.6–82.8 (80.1 ± 1.2)	73.3–76.6 (74.6 ± 1.2)	71.7–74.2 (73.5 ± 0.9)	72.0–78.6 (74.1 ± 2.0)	71.2–76.1 (73.5 ± 1.6)	68.5–76.2 (73.8 ± 2.4)
CPL	11.2–15.5 (13.1 ± 1.3)	14.3–17.8 (15.7 ± 1.0)	11.5–13.4 (12.4 ± 0.6)	11.6–14.1 (12.2 ± 0.8)	10.1–12.5 (11.0 ± 0.8)	11.0–14.5 (12.6 ± 1.0)	10.2–14.3 (11.5 ± 1.2)
CPD	9.7–11.7 (10.6 ± 0.8)	10.0–11.6 (10.8 ± 0.5)	10.1–11.3 (10.8 ± 0.4)	9.5–11.3 (10.2 ± 0.6)	9.8–12.0 (10.7 ± 0.8)	12.2–14.8 (13.0 ± 0.9)	8.5–13.4 (10.9 ± 1.5)
Percentage of HL (%)							
ED	13.6–19.5 (15.9 ± 1.7)	11.2–15.2 (12.4 ± 1.2)	10.4–14.9 (12.9 ± 1.7)	9.2–13.5 (10.9 ± 1.3)	9.0–14.2 (11.9 ± 1.6)	11.1–19.7 (15.1 ± 2.3)	12.5–16.8 (14.7 ± 1.7)
IW	41.8–47.3 (43.9 ± 1.7)	34.6–44.6 (41.3 ± 2.5)	42.3–47.9 (44.9 ± 2.1)	44.1–51.9 (48.1 ± 2.7)	39.9–45.2 (42.2 ± 2.1)	41.1–49.9 (46.1 ± 2.5)	34.5–45.6 (40.3 ± 3.2)
STL	30.2–34.7 (32.8 ± 1.6)	37.7–43.3 (40.7 ± 1.8)	31.2–40.2 (36.0 ± 3.3)	30.3–40.5 (35.1 ± 3.3)	33.5–40.5 (36.4 ± 2.0)	34.4–40.9 (37.3 ± 2.4)	31.2–37.9 (34.0 ± 2.0)
DAN	29.6–36.4 (33.0 ± 2.2)	23.6–39.2 (29.7 ± 3.9)	30.6–36.5 (34.1 ± 1.9)	29.1–35.6 (32.5 ± 2.3)	31.4–35.1 (32.8 ± 1.4)	31.6–38.0 (35.0 ± 2.6)	26.4–37.1 (30.4 ± 2.9)
DPN	34.0–39.1 (37.2 ± 1.8)	33.8–38.9 (36.5 ± 1.5)	34.5–40.5 (37.7 ± 1.9)	34.0–37.8 (36.0 ± 1.3)	33.8–38.2 (36.0 ± 1.7)	37.6–42.8 (39.3 ± 1.6)	34.3–41.6 (36.7 ± 2.3)
DAPN	8.0–11.1 (9.6 ± 0.9)	6.3–10.6 (7.7 ± 1.3)	8.2–13.2 (10.6 ± 2.0)	7.5–11.9 (10.5 ± 1.4)	8.0–13.0 (9.9 ± 1.7)	10.1–12.3 (11.0 ± 0.7)	8.1–12.4 (10.3 ± 1.6)
MBL	43.3–55.9 (48.0 ± 4.4)	36.4–50.8 (43.3 ± 4.7)	52.9–61.7 (56.1 ± 2.7)	37.3–55.4 (45.5 ± 5.3)	41.5–55.6 (46.0 ± 4.5)	38.3–56.3 (48.7 ± 5.3)	33.9–55.9 (45.5 ± 8.0)
OSBL	50.0–69.6 (59.4 ± 6.6)	47.4–58.7 (54.4 ± 4.4)	64.8–71.6 (68.8 ± 2.6)	41.3–52.5 (48.2 ± 5.6)	43.9–60.7 (51.5 ± 6.4)	47.2–66.5 (57.4 ± 5.8)	39.2–61.4 (53.9 ± 7.1)
ISBL	25.5–48.5 (38.2 ± 8.6)	25.6–37.4 (33.1 ± 3.4)	30.6–51.5 (42.1 ± 6.4)	28.8–36.9 (33.1 ± 2.9)	28.7–40.8 (33.1 ± 4.6)	35.9–40.6 (37.8 ± 2.6)	21.1–47.9 (33.1 ± 7.4)
Percentage of CPL (%)							
CPD	67.2–98.7 (81.6 ± 8.9)	63.4–78.0 (68.7 ± 5.1)	75.1–97.5 (87.7 ± 6.8)	74.7–90.6 (83.3 ± 4.6)	95.2–118.2 (98.5 ± 10.1)	95.0–125.0 (103.4 ± 10.2)	73.8–131.0 (96.7 ± 20.5)
Habitat types	Small pools on surface where groundwater overflowed	Karst cave under mountain	Water outlet of underground karst cave	Open stream	Water of underground karst cave	Surface stream	Underground karst cave

branched pelvic-fin rays, three unbranched and five branched anal-fin rays, 13 or 14 branched caudal-fin rays, and 11 or 12 inner-gill rakers on first gill arch (in 3 specimens).

Body elongated and cylindrical, deepest body depth in front of dorsal-fin origin, deepest body depth 16–18% of standard length (SL). Head slightly depressed and flattened, maximum head width greater than deepest head height. Anterior

Table 2. Uncorrected *p*-distances (%) between seven species in the genus *Oreonectes* based on mitochondrial Cyt *b* genes.

ID	Species	1	2	3	4	5	6
1	*Oreonectes andongensis* sp. nov.						
2	*Oreonectes damingshanensis*	6.1					
3	*Oreonectes guananensis*	7.5	8.7				
4	*Oreonectes guilinensis*	7.0	7.2	8.8			
5	*Oreonectes luochengensis*	6.4	7.5	4.8	8.1		
6	*Oreonectes platycephalus*	6.6	6.7	8.7	6.5	7.9	
7	*Oreonectes polystigmus*	6.0	6.0	8.3	7.3	7.4	6.4

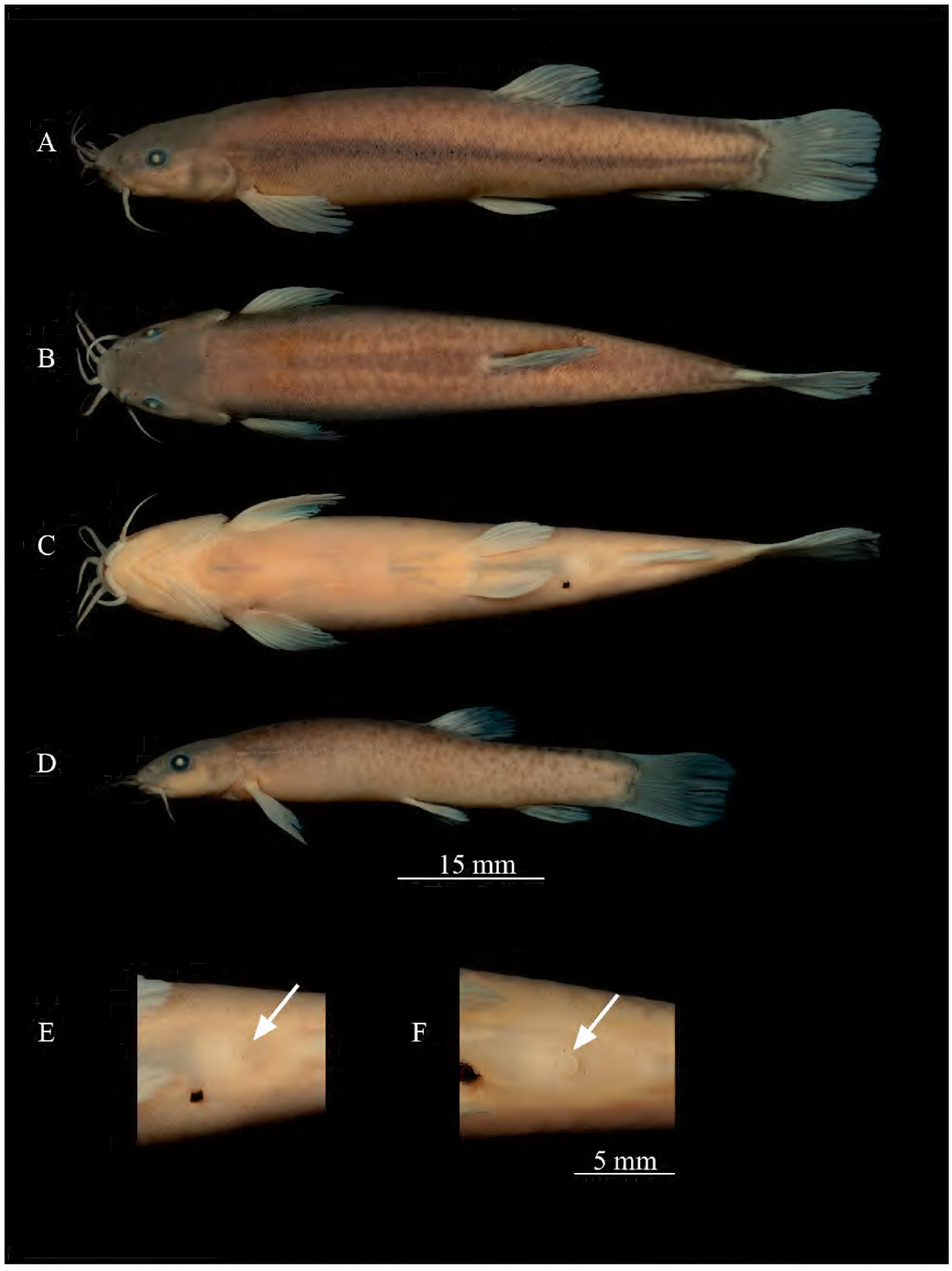

Figure 2. *Oreonectes andongensis* sp. nov. **A–C** lateral, dorsal and ventral views of holotype GXNU20220601 (♀), **D** lateral view of paratype GXNU20220610 (♂), **E, F** gonadal structure of female (**E**) and male (**F**).

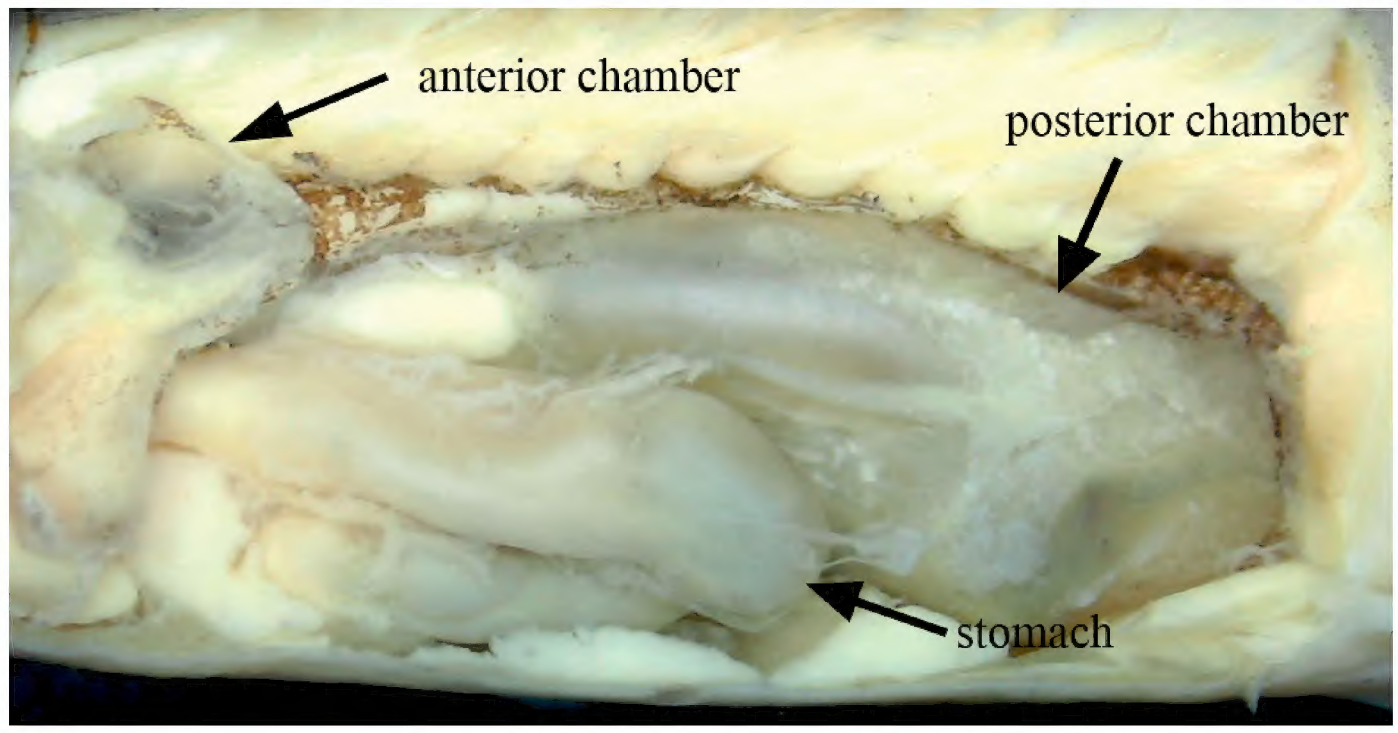

Figure 3. Stomach, anterior chamber, and posterior chamber of *Oreonectes andongensis* sp. nov.

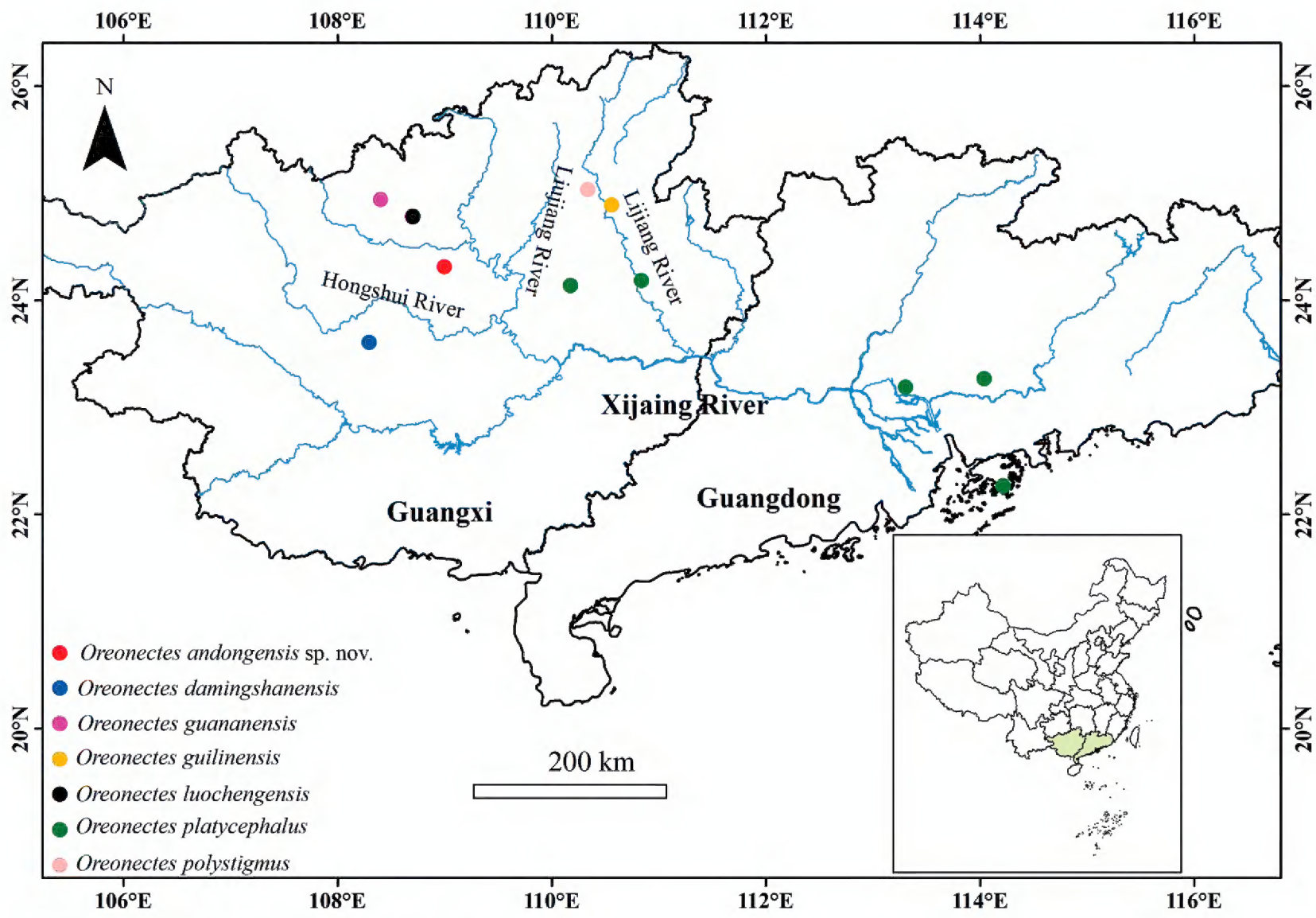

Figure 4. Distribution of *Oreonectes* in southern China.

and posterior nostrils adjacent, distance shorter than diameter of posterior nostril. Base of anterior nostril tube-shaped with elongated barbel-like tip; barbel longer than anterior nostril tube. Eyes normal, eye diameter 14–20% of head length (HL). Snout obtuse, snout length shorter than postorbital length. Mouth inferior, lips smooth, center of lower lip with notch. Three pairs of barbels, inner rostral barbel length 23–49% of HL, extending to the anterior margin of eye; outer rostral barbel length 50–70% of HL, extending to the posterior margin of eye; maxillary barbel length 43–56% of HL, not reaching to posterior margin of opercula.

Dorsal-fin origin slightly posterior to pelvic-fin origin. Predorsal length 58–62% of SL. Tip of pectoral fin not reaching half of distance between origin of pectoral and pelvic fins. Tip of pelvic fin not reaching anus. Short distance (two times eye diameter) between anal-fin origin and anus. Caudal fin straight.

Figure 5. Habitat of *Oreonectes andongensis* sp. nov.

Caudal peduncle without adipose crests along both dorsal and ventral sides. Caudal peduncle depth 67–99% of caudal peduncle length. Whole body covered by scales except head. Lateral line incomplete, with 8–16 pores. Cephalic lateral line system developed, with 6–9 supraorbital pores, 3 + 8–10 infraorbital pores, three or four canal pores, and 6–8 pre-operculo-mandibular canal pores.

Stomach U-shaped. Swim bladder divided into two chambers, anterior chamber covered by dumbbell-shaped bony capsule, and posterior chamber developed with posterior extremely reaching below dorsal-fin origin.

Coloration. In formalin-fixed specimens, dorsal surface and trunk of body yellowish, while abdomen appears grayish. Additionally, dorsal surface and flank with small spots or short bars. Dorsal and caudal fins with black speckles. Longitudinal stripe extending from gill opening to caudal peduncle in female, lacking in males.

Sexual dimorphism. In reproductive season, males possess large genital papilla located immediately posterior to anus, unclear in females; gonad opens at end of fleshy prominence.

Distribution and habitat. *Oreonectes andongensis* sp. nov. was collected from Andong Township, Xincheng County, Laibin City, Guangxi Zhuang Autonomous Region, China, a tributary of the Hongshui River in Xijiang River basin. During the rainy season, specimens were gathered from small pools on the surface where groundwater had overflowed. *Troglonectes canlinensis* Li et al., 2023 specimens were also collected from the same pool.

Etymology. The nomenclature of this species is derived from the Chinese pinyin of Andong, the name of the village where the specimens were obtained. We suggest the Chinese common name as “安东岭鳅”.

Remarks. *Oreonectes andongensis* sp. nov. can be distinguished from *O. damingshanensis* by the six branched pelvic-fin rays (vs 7), a dorsal-fin origin slightly posterior to pelvic-fin origin (vs posterior to pelvic-fin origin obviously), and 11 or 12 inner gill rakers on the first gill arch (vs 9), from *O. guananensis* by six branched pelvic-fin rays (vs 7 or 8), dorsal-fin origin slightly posterior to pelvic-fin origin (vs opposite to pelvic-fin origin), caudal with irregular black markings (vs without irregular black markings), and maxillary barbel not reaching to the gill cover (vs reaching to the gill cover), from *O. guilinensis* by lateral line pores 8–16 (vs 4–6), tip of pelvic fin not reaching to anus (vs exceeding to anus), and maxillary barbel not reaching to the opercula (vs reaching to posterior margin of the eye), from *O. luochengensis* by cephalic lateral line system present (vs absent), abdomen between pectoral-fin origin to pelvic-fin origin scaled (vs scaleless), from *O. platycephalus* by posterior chamber of swim bladder developed (vs reduced), dorsal-fin origin slightly posterior to pelvic-fin origin (vs posterior to pelvic-fin origin obviously), seven branched dorsal-fin rays (vs 8 or 9), and six branched pelvic-fin rays (vs 8), from *O. polystigmus* by tip of pelvic fin not reaching to anus (vs exceeding to anus), and maxillary barbel not reaching to the opercula (vs reaching to the pectoral-fin origin).

Key to species of the genus Oreonectes

1 Body colorless ..... ***O. luochengensis***
– Color pattern present **2**
2 Dorsal-fin origin opposite to pelvic-fin origin ..... ***O. guananensis***
– Dorsal-fin origin posterior to pelvic-fin origin **3**
3 Tip of pelvic fin exceeding anus **4**
– Tip of pelvic fin not reaching anus **5**
4 Six branched dorsal-fin rays ..... ***O. guilinensis***
– Seven branched dorsal-fin rays ..... ***O. polystigmus***
5 Posterior chamber of swim bladder reduced ..... ***O. platycephalus***
– Posterior chamber of swim bladder developed **6**
6 Six branched pelvic fin rays, 11 or 12 inner gill rakers on first gill arch ..... ***Oreonectes andongensis* sp. nov.**
– Seven branched pelvic fin rays, 9 inner gill rakers on first gill arch ..... ***O. damingshanensis***

Discussion

The distinct lineage of *Oreonectes andongensis* sp. nov. marked by an uncorrected *p*-distance of 6.0% from *O. polystigmus*, along with notable morphological differences, substantiates its validity as a new species. With the addition of the new species, the genus *Oreonectes* now comprises seven species: *Oreonectes andongensis* sp. nov., *O. damingshanensis*, *O. guananensis*, *O. guilinensis*, *O. luochengensis*, *O. platycephalus*, and *O. polystigmus*.

Oreonectes andongensis sp. nov. exhibited sexual dimorphism. Notably, males contained larger genital papilla located immediately posterior to the anus, with the gonads opening at the end of a fleshy prominence. Zhu (1989) noted that this structure may be related to the special breeding habits of *Oreonectes*. Additionally, most species of *Oreonectes* possess that developed

posterior chamber of swim bladder except *O. platycephalus*. Zhu (1989) speculated that the posterior chamber of swim bladder related to adapting to habitat. *Oreonectes andongensis* sp. nov. and other congeneric species (except *O. platycephalus*) possess developed posterior chamber of swim bladder, and mainly habitat in pools surround subterrane river, but *O. platycephalus* inhabit in running water of upper reaches of the river.

Within the genus *Oreonectes*, *O. platycephalus* has a broader distribution, both within and beyond Guangxi, whereas the other species are exclusively found in Guangxi. In areas within Guangxi, *O. platycephalus* coexists with the other species, with their distribution overlapping along certain routes of *O. platycephalus* (Tang 2012). Wang (2022) suggested that the ancestors of the Nemacheilidae family in southwest China emerged around 26.19 million years ago (approximately the Late Oligocene). The uplift of the Tibetan Plateau led to the development of the Pearl River occurred concurrently (Zhang et al. 2022). This expansion towards the Pearl River Delta area likely facilitated the spread of *Oreonectes*. As the caves in southwest China continued to develop, some fish species entered these habitats, evolving traits suited to cave living, such as eye degeneration, loss of scales, and lack of pigmentation.

Comparative material

All specimens were collected from Guangxi; their measurements are given in Appendix 2.

Oreonectes guananensis, KIZ2010003067, holotype, 71.5mm SL, KIZ2010003068–072, paratypes, 5 ex., 51.0–71.9 mm SL, Guan'an Village, Changmei Town, Huanjiang County, Guangxi.

Oreonectes guilinensis, ASIZB208001, holotype, 73.5 mm SL, ASIZB208002–007, paratypes, 6 ex., 52.0–68.3 mm, Shigumen Village Xingping Town, Yangshuo County, Guilin City, Guangxi.

Oreonectes luochengensis, KIZ2010003073, holotype, 71.2 mm SL, KIZ2010003074–077, KIZ2010003242–244, paratypes, 7 ex., 61.3–74.7 mm SL, Tianhe Town, Luocheng County, Guangxi.

Oreonectes platycephalus, KIZ2003007105–106, 63.2–64.2 mm SL, KIZ2003007110, 60.9 mm SL, KIZ2005006211–212, 38.7–43.1 mm SL, KIZ2005006214–216, 45.6–47.7 mm SL, 8 ex., Fenzhan Village, Jinxiu County, Guangxi.

Oreonectes polystigmus, KIZ2001004626, holotype, 54.7 mm SL, KIZ2002004627–634, paratypes, 9 ex., 33.7–52.4 mm SL, Dabu Village, Guilin City, Guangxi.

Acknowledgements

We are grateful to Ying-Nan Wang, Institute of Zoology, Chinese Academy of Sciences, Beijing (ASIZB) and Rui Min, Kunming Institute of Zoology, Chinese Academy of Sciences (KIZ) for providing *Oreonectes* specimens, Jun-Kai Huang for taking photographs of the new species, and Christine Watts for English correction and suggestions.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

This study was funded by the Guangxi Natural Science Foundation Project (2022GXNSFAA035563 and 2020GXNSFAA238031), Key Laboratory of Ecology of Rare and Endangered Species and Environmental Protection (Guangxi Normal University), Ministry of Education, China (ERESEP2022Z05), and Biodiversity Survey and Assessment Project Conducted in the Nanling Biodiversity Conservation Priority Area (Liuzhou area), Guangxi (11N00760329320231202).

Author contributions

XML measured the specimens, analyzed the data, constructed the phylogenetic tree, and prepared the manuscript; RGY provided the funding for the field survey; LND conceived and designed the study and reviewed the manuscript before submission; FGL conducted field surveys and provided funding for complete mitochondrial genomes. All authors have read and agreed to the published version of the manuscript.

Author ORCIDs

Xue-Ming Luo https://orcid.org/0000-0001-6441-4817
Li-Na Du https://orcid.org/0000-0002-2246-643X

Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

References

Deng HQ, Wen HM, Xiao N, Zhou J (2016a) A new blind species of the cave genus *Oreonectes* from Guizhou, China (Nemacheilinae). ZooKeys 637: 47–59. https://doi.org/10.3897/zookeys.637.10202

Deng HQ, Xiao N, Hou XF, Zhou J (2016b) A new species (Cypriniformes: Nemacheilidae) from Guizhou, China. Zootaxa 4132(1): 143–150. https://doi.org/10.11646/zootaxa.4132.1.13

Du LN, Chen XY, Yang JX (2008) A review of the Nemacheilinae genus *Oreonectes* Günther with descriptions of two new species (Teleostei: Balitoridae). Zootaxa 1729(1): 23–36. https://doi.org/10.11646/zootaxa.1729.1.3

Du LN, Yang J, Min R, Chen XY, Yang JX (2021) A review of the Cypriniform tribe Yunnanilini Prokofiev, 2010 from China, with an emphasis on five genera based on morphologies and complete mitochondrial genomes of some species. Zoological Research 42(3): 310–334. https://doi.org/10.24272/j.issn.2095-8137.2020.229

Du LN, Li SJ, Xu F, Luo T, Luo FG, Yu GH, Zhou J (2023) Clarification of phylogenetic relationships among Chinese Nemacheilids with tube-shaped anterior nostrils, with a description of a new genus and two new species. Journal of Zoo-

logical Systematics and Evolutionary Research 2023: e3600085. https://doi.org/10.1155/2023/3600085

Edgar RC (2004) MUSCLE: Multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32(5): 1792–1797. https://doi.org/10.1093/nar/gkh340

Günther A (1868) Catalogue of the Fishes in the British Museum. Trustees of the British Museum, London, 369 pp.

Huang AM, Du LN, Chen XY, Yang JX (2009) *Oreonectes macrolepis*, a new nemacheiline loach of genus *Oreonectes* (Balitoridae) from Guangxi, China. Zoological Research 30(4): 445–448. https://doi.org/10.3724/SP.J.1141.2009.04445

Huang JQ, Yang J, Wu ZQ, Zhao YH (2020) *Oreonectes guilinensis* (Teleostei, Cypriniformes, Nemacheilidae), a new loach species from Guangxi, China. Journal of Fish Biology 96(1): 111–119. https://doi.org/10.1111/jfb.14191

Kottelat M (1990) Indochinese Nemacheilines: A Revision of Nemacheiline Loaches (Pisces, Cypriniformes) of Thailand, Burma, Laos, Cambodia and Southern Vietnam. München, United Germany, 262 pp.

Kottelat M (2012) Conspectus cobitidum: An inventory of the loaches of the world (Teleostei: Cypriniformes: Cobitoidei). The Raffles Bulletin of Zoology 26(6): 1–199. https://doi.org/10.1016/j.sleep.2014.01.018

Lan JH, Yang JX, Chen YR (1995) Tow new species of the subfamily Nemacheilinae from Guangxi, China (Cypriniformes: Cobitidae). Dong Wu Fen Lei Xue Bao 20(3): 366–372. [in Chinese]

Lan JH, Gan X, Wu TJ, Yang J (2013) Cave Fishes of Guangxi, China. Science Press, Beijing, 68–83. [in Chinese]

Lanfear R, Frandsen PB, Wright AM, Senfeld T, Calcott B (2017) PartitionFinder 2: New methods for selecting partitioned models of evolution for molecular and morphological phylogenetic analyses. Molecular Biology and Evolution 34(3): 772–773. https://doi.org/10.1093/molbev/msw260

Li SJ, Ge JK, Bao CY, Du LN, Luo FG, Zhou TX (2023) *Troglonectes canlinensis* sp. nov. (Teleostei: Nemacheilidae), A new troglomorphic loach from Guangxi, China. Animals 13(10): e1712. https://doi.org/10.3390/ani13101712

Liu X, Deng HQ, Liu ZJ, Zhou J (2019) Reassignment of *Triplophysa jiarongensis* (Cypriniformes: Nemacheilidae) to *Oreonectes* Günther,1868. Zootaxa 4565(3): 398–406. https://doi.org/10.11646/zootaxa.4565.3.6

Luo T, Yang Q, Wu L, Wang YL, Zhou JJ, Deng HQ, Xiao N, Zhou J (2023) Phylogenetic relationships of Nemacheilidae cavefish (Heminoemacheilus, Oreonectes, Yunnanilus, Paranemachilus, and Troglonectes) revealed by analysis of mitochondrial genome and seven nuclear genes. Zoological Research 44(4): 693–697. https://doi.org/10.24272/j.issn.2095-8137.2022.266

Ronquist F, Teslenko M, Van DMP, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choicem across a large model space. Systematic Biology 61(3): 539–542. https://doi.org/10.1093/sysbio/sys029

Tamura K, Stecher G, Kumar S (2021) MEGA11: Molecular Evolutionary Genetics Analysis Version 11. Molecular Biology and Evolution 38(7): 3022–3027. https://doi.org/10.1093/molbev/msab120

Tang L, Zhao YH, Zhang CG (2012) A new blind loach, *Oreonectes elongatus* sp. nov. (Cypriniformes: Balitoridae) from Guangxi, China. Environmental Biology of Fishes 93(4): 483–449. https://doi.org/10.1007/s10641-011-9943-7

Tang L (2012) Study on Taxonomy and Distribution Patterns of the Genera *Oreonectes* and *Troglonectes* gen. nov. (Cypriniformes: Balitoridae) (Master's thesis). University of Chinese Academy of Sciences, Beijing. [in Chinese]

Wang YL (2022) Systematic taxonomy of the genus *Oreonectes* (Master's thesis). Guizhou Normal University, Guiyang. [In Chinese]

Xue D (2010) Guide to collection, preservation, identification and information share of animal specimens. Standard Press of China, Beijing, 103–125. [in Chinese]

Yang J, Wu TJ, Wei RF, Yang JX (2011a) A new loach, *Oreonectes luochengensis* sp. nov. (Cypriniformes: Balitoridae) from Guangxi, China. Zoological Research 32(2): 208–211. https://doi.org/10.3724/SP.J.1141.2011.02208 [in Chinese]

Yang Q, Wei ML, Lan JH, Yang Q (2011b) A new species of the genus *Oreonectes* (Balitoridae) from Guangxi, China. Guangxi Shifan Daxue Xuebao. Ziran Kexue Ban 29(1): 72–75. https://doi.org/10.16088/j.issn.1001–6600.2011.01.037

Yu J, Luo T, Lan CT, Zhou JJ, Deng HQ, Xiao N, Zhou J (2023) *Oreonectes damingshanensis* (Cypriniformes, Nemacheilidae), a new species of stream fish from Guangxi, Southwest China. ZooKeys 1180: 81–104. https://doi.org/10.3897/zookeys.1180.104645

Zhang CG, Zhao YH (2016) Species Diversity and Distribution of Inland Fishes in China. Science Press, Beijing, 130–148. [in Chinese]

Zhang ZL, Zhao YH, Zhang CG (2006) A new blind loach, *Oreonectes translucens* (Teleostei: Cypriniformes: Nemacheilinae), from Guangxi, China. Zoological Studies 45(4): 611–615.

Zhang XT, Xiang XH, Zhao M, Cui YC, Zhang H (2022) Coupling relationship between Pearl river water system evolution and East Asian Terrain inversion. Earth Science 47(7): 2410–2420. https://doi.org/10.3799/dqkx.2022.002

Zheng BS (1981) Freshwater Fishes of Guangxi Province. Guangxi People's Publishers, Nanning, 93–94. [in Chinese]

Zhu SQ (1989) The Loaches of the Subfamily Nemacheilinae in China (Cypriniformes: Cobitidae). Jiangsu Science and Technology Publishing House, Nanjing, China, 22–26. [in Chinese]

Appendix 1

Table A1. Localities, voucher information, and GenBank numbers for all samples used in this paper.

Species	Locality	Voucher	GenBank number
Triplophysa nasobarbatula	Libo County, Guizhou, China	GZNU20190114001	ON116529
Triplophysa baotianensis	Nanpanjiang River, Panzhou City, Guizhou, China	GZNU20180421005	NC056365
Triplophysa zhenfengensis	Xingren County, Guangxi, China	GZNU20180419002	NC063617
Traccatichthys pulcher	Daxin County, Guangxi, China	Tissue ID: GX1	ON116516
Traccatichthys zispi	Hainan, China	Tissue ID:HN01	ON116518
Traccatichthys taeniatus	N/A	N/A	NC031581
Lefua nikkonis	N/A	N/A	NC027662
Lefua costata	N/A	N/A	NC029385
Lefua echigonia	N/A	N/A	NC004696
Oreonectes platycephalus	Shenzhen City, Guangdong, China	GZNU2020112501	ON116528
Oreonectes guilinensis	Xingping Town, Yangshuo County, Guangxi, China	N/A	MN239094
Oreonectes damingshanensis	Leping Village, Guling Town, Mashan County, Guangxi, China	GZNU20230216011	OQ754117
Oreonectes damingshanensis	Leping Village, Guling Town, Mashan County, Guangxi, China	GZNU20230216012	OQ754118
Oreonectes damingshanensis	Damingshan Mountain, Shanglin County, Guangxi, China	GZNU 2020112502	ON116496
Oreonectes polystigmus	Dabu Town, Yanshan District, Guilin, Guangxi, China	GZNU2020011501	ON116514
Oreonectes andongensis sp. nov.	Andong Town, Xincheng County, Laibin City, Guangxi, China	N/A	OR188128

Species	Locality	Voucher	GenBank number
Oreonectes andongensis sp. nov.	Andong Town, Xincheng County, Laibin City, Guangxi, China	N/A	OR712240
Oreonectes andongensis sp. nov.	Andong Town, Xincheng County, Laibin City, Guangxi, China	N/A	OR712241
Oreonectes luochengensis	Tianhe Town, Luocheng County, Guangxi, China	GZNU2020011502	ON116495
Oreonectes guananensis	Changmei Town, Huanjiang County, Guangxi, China	GZNU2020073102	ON116507
Guinemachilus longibarbatus	Hechi City, Guangxi, China	GZNU20210823001	ON148334
Guinemachilus pseudopulcherrimus	Dongmiao Village, Du'An County, Hechi City, Guangxi, China	D1925	OQ024375
Micronemacheilus cruciatus	N/A	N/A	NC033960
Micronemacheilus pulcherrimus	Duan County, Hechi City, Guangxi, China	GZNU20210609004	ON116493
Karstsinnectes parva	Ande Town, Jingxi City, Guangxi, China	Tissue ID: JTQ02	ON116520
Karstsinnectes anophthalmus	Leiping Town, Daxin County, Guangxi, China	GZNU2019011310	ON116513
Karstsinnectes acridorsalis	Bamu Town, Tiane County, Guangxi, China	GZNU2020	ON116515
Troglonectes translucens	Xiaao Town, Duan County, Guangxi, China	GZNU 2020082302	ON116510
Troglonectes macrolepis	Dacai Town, Huanjiang County, Guangxi, China	GZNU2019122202	NC073129
Troglonectes microphthalmus	Tianhe Town, Luocheng County, Guangxi, China	GZNU2020041601	NC073127
Troglonectes canlinensis	Andong Town, Xincheng County, Liuzhou City, Guangxi, China	c FFL-2023	OQ129618
Troglonectes furcocaudalis	Yongle Town, Rongshui County, Guangxi, China	GZNU2020042701	ON116512
Paranemachilus zhengbaoshani	Duan County, Guangxi, China	GZNU20210526001	ON116530
Paranemachilus chongzuo	Daxin County, Chongzuo City, Guangxi, China	N/A	MW532082
Paranemachilus jinxiensis	N/A	N/A	NC039380
Paranemachilus genilepis	N/A	N/A	MT845213
Yunnanilus analis	N/A	N/A	MW729320
Yunnanilus pleurotaenia	N/A	QT95	MW192447
Yunnanilus jiuchiensis	Jiuchi County, Penzhou City, Sichuan, China	N/A	MW532080

Appendix 2

Table A2. Measurements of the eight species of *Oreonectes*. All units are in mm.

Species	Voucher number	TL	SL	BD	BW	HL	HD	HW	ED	IW	STL	PDL	PPL	PVL	PAL	PANL	CPL
O. andongensis sp. nov.	GXNU20220601	74.9	60.2	10.8	9.1	13.3	7.5	10.3	2.0	5.9	4.6	37.5	12.6	35.0	49.7	46.6	6.8
	GXNU20220602	68.7	56.4	10.0	7.5	12.7	7.0	8.8	2.1	5.3	3.9	35.0	10.9	32.4	46.2	42.1	7.0
	GXNU20220603	67.2	54.4	9.4	6.5	12.2	6.2	8.3	1.8	5.1	3.9	31.4	10.8	30.2	44.2	40.6	6.4
	GXNU20220604	61.4	50.9	8.0	6.7	10.8	5.8	7.8	1.6	5.1	3.6	29.7	10.6	27.6	41.3	36.9	6.5
	GXNU20220605	57.3	47.5	7.6	6.1	10.2	5.6	7.1	1.4	4.6	3.5	28.0	10.7	26.8	38.3	34.9	6.4
	GXNU20220606	52.3	40.8	6.8	5.2	8.9	5.2	6.5	1.4	3.9	3.1	23.7	8.8	22.4	32.5	29.4	4.9
	GXNU20220607	45.9	36.7	6.4	4.5	9.0	4.5	6.1	1.3	4.0	2.9	22.7	8.7	21.3	29.8	27.9	4.9
	GXNU20220608	49.6	40.4	6.4	4.7	9.0	4.8	5.9	1.8	3.8	2.9	24.0	8.5	22.2	32.4	29.3	5.4
	GXNU20220609	48.1	38.4	6.4	4.7	8.4	4.9	6.1	1.4	3.8	2.9	22.9	7.7	21.0	30.2	27.9	5.8
	GXNU20220610	46.1	36.5	5.9	4.2	8.5	4.5	5.6	1.5	3.7	2.6	22.4	8.0	20.7	29.6	27.3	5.7
O. guananensis	KIZ2010003067	90.2	71.5	11.8	8.7	16.6	8.3	11.3	1.8	7.4	5.2	41.6	15.7	41.0	58.3	52.8	9.6
	KIZ2010003068	76.8	61.4	10.1	7.1	13.9	7.2	9.7	1.8	6.4	4.4	36.0	13.5	35.3	49.6	47.1	7.8
	KIZ2010003069	69.6	56.3	9.9	5.3	12.3	6.3	8.3	1.7	5.9	5.0	33.5	12.2	31.2	45.7	41.3	6.8
	KIZ2010003070	66.2	53.3	10.5	5.2	12.3	6.4	9.0	1.8	5.2	4.6	30.5	11.8	29.7	43.5	39.9	6.4
	KIZ2010003071	62.9	51.0	9.7	6.1	11.2	5.8	8.4	1.6	5.2	4.2	29.3	10.9	28.3	39.4	37.7	6.5
	KIZ2010003072	88.5	71.9	11.7	9.4	16.6	7.8	11.3	1.7	7.0	6.2	42.6	16.6	41.3	58.5	54.4	8.3
O. guilinensis	ASIZB208001	89.7	73.5	12.3	9.3	16.0	10.3	12.2	1.6	7.8	6.1	43.4	38.6	39.9	39.7	40.0	31.4
	ASIZB208002	81.4	67.3	12.3	9.1	14.1	8.1	10.7	1.3	7.0	5.0	15.0	12.9	13.8	12.0	11.4	10.2
	ASIZB208003	82.8	68.3	12.4	10.1	14.8	9.1	12.1	2.0	7.5	6.0	40.4	37.0	38.1	37.5	36.4	29.1
	ASIZB208004	83.8	67.1	12.4	9.7	14.5	9.0	11.7	1.5	6.7	4.4	59.7	54.2	53.7	53.2	53.0	41.3
	ASIZB208005	82.2	67.6	12.4	9.3	14.3	8.2	10.4	1.7	6.3	4.5	54.4	49.8	49.0	48.7	49.7	38.6
	ASIZB208006	63.2	52.0	9.5	7.4	12.6	7.9	9.9	1.3	5.7	4.4	8.8	7.8	8.5	7.9	9.5	6.3
	ASIZB208007	79.6	65.5	11.8	9.1	13.3	8.6	11.0	1.5	6.9	4.6	7.3	6.4	7.7	6.9	7.1	5.1

Species	Voucher number	TL	SL	BD	BW	HL	HD	HW	ED	IW	STL	PDL	PPL	PVL	PAL	PANL	CPL
O. luochengensis	KIZ2010003073	86.0	71.2	11.4	7.4	14.7	11.6	10.7	2.1	6.0	5.5	42.5	14.4	39.4	58.2	52.8	7.3
	KIZ2010003074	83.9	67.0	11.5	6.6	15.5	12.0	9.2	2.0	6.2	5.2	39.6	13.2	36.4	53.7	48.7	6.9
	KIZ2010003075	86.3	68.8	11.8	7.8	15.3	12.5	10.4	1.8	6.7	5.8	41.8	14.2	38.4	55.7	50.3	7.8
	KIZ2010003076	87.0	71.2	13.0	8.6	15.9	12.4	10.0	1.6	6.9	5.5	42.4	14.3	39.7	57.2	51.6	7.4
	KIZ2010003077	77.2	62.2	10.7	6.7	15.1	11.7	10.5	2.0	6.7	5.4	37.8	13.6	37.5	51.3	48.9	7.0
	KIZ2010003242	84.9	68.6	12.6	6.9	15.3	11.6	10.1	1.8	6.2	5.5	40.2	13.1	37.2	55.3	49.4	6.9
	KIZ2010003243	92.1	74.7	12.9	8.9	16.6	13.1	11.5	1.5	7.5	6.1	47.2	15.2	44.4	62.0	55.5	8.7
	KIZ2010003244	76.4	61.3	10.3	6.2	13.3	10.9	9.1	1.6	5.4	5.4	35.5	12.4	33.9	49.6	46.2	7.6
O. platycephalus	KIZ2003007105	82.5	64.2	12.4	6.8	16.3	12.5	11.2	2.4	6.7	6.1	41.5	14.1	36.2	51.3	48.8	7.1
	KIZ2003007106	80.1	63.2	12.0	6.0	13.2	11.0	9.9	1.9	5.9	4.6	41.1	14.4	35.7	50.6	46.5	7.7
	KIZ2003007110	75.9	60.9	10.9	6.2	13.0	10.7	9.7	1.4	5.9	5.0	38.3	11.6	34.1	47.2	45.7	7.8
	KIZ2005006211	56.7	43.1	7.2	4.6	10.5	8.6	7.0	1.5	5.0	4.3	26.7	9.6	22.8	34.5	31.7	6.3
	KIZ2005006212	49.6	38.7	6.2	4.5	9.0	7.5	6.1	1.8	4.0	3.3	23.3	8.5	21.6	30.4	28.8	5.1
	KIZ2005006214	56.9	46.5	6.9	4.7	10.4	8.5	7.2	1.7	5.0	4.2	28.4	8.4	24.6	36.3	33.3	5.6
	KIZ2005006215	61.6	47.7	7.8	5.1	10.9	9.4	7.0	1.7	5.0	3.7	28.6	10.5	25.2	38.4	34.6	6.4
	KIZ2005006216	58.0	45.6	7.8	4.8	10.0	8.2	6.7	1.5	5.0	3.5	27.4	9.2	23.8	35.9	32.5	5.5
O. polystigmus	KIZ2001004626	67.8	54.7	10.5	6.5	12.9	7.2	9.6	1.7	5.9	4.5	33.1	11.6	30.9	44.1	39.9	5.6
	KIZ2001004627	62.7	52.4	6.6	3.9	11.9	5.9	7.7	1.5	4.8	4.3	31.4	11.5	28.8	41.7	39.2	6.1
O. polystigmus	KIZ2001004628	45.8	37.4	5.3	2.9	8.9	4.2	5.1	1.2	3.3	2.9	23.9	7.2	20.4	30.6	28.5	4.3
	KIZ2001004629	51.9	42.5	7.5	3.2	9.5	5.1	5.9	1.6	3.8	3.3	25.6	9.2	22.9	32.5	29.1	6.1
	KIZ2001004630	41.8	33.7	6.6	3.1	8.2	4.3	5.2	1.4	3.6	2.8	19.9	8.5	18.8	27.4	25.0	3.5
	KIZ2001004631	44.5	36.0	5.8	3.0	8.6	4.6	5.9	1.4	3.4	3.3	21.8	8.3	20.6	28.9	27.5	4.0
	KIZ2001004632	49.5	39.9	6.9	3.5	9.6	5.1	6.2	1.2	3.8	3.0	25.5	9.3	21.3	32.0	30.1	4.7
	KIZ2001004633	51.0	41.2	6.6	3.7	9.9	4.9	6.3	1.6	3.4	3.4	24.5	8.5	22.7	32.8	29.2	4.2
	KIZ2001004634	55.2	44.4	6.6	4.0	10.5	5.6	7.4	1.5	4.5	3.3	26.8	10.0	24.4	35.3	33.4	5.2

Table A2. Continued.

Species	Voucher number	CPD	DFL	DFBL	PFL	PFBL	VFL	VFBL	AFL	AFBL	MBL	OSBL	ISBL	DAN	DPN	DAPN
O. andongensis sp. nov.	GXNU20220601	6.7	10.8	6.9	11.4	2.3	8.2	2.1	8.7	4.3	6.9	8.3	6.3	4.3	4.7	1.5
	GXNU20220602	6.6	10.7	5.8	9.1	2.3	7.1	2.2	8.7	4.4	7.0	7.9	5.7	4.6	4.8	1.2
	GXNU20220603	5.3	10.5	6.3	9.6	2.1	7.3	2.0	9.4	4.0	6.0	7.8	5.5	4.1	4.7	1.2
	GXNU20220604	5.2	9.3	5.3	8.2	2.2	5.7	2.0	7.4	3.9	4.7	7.3	5.2	3.6	4.2	1.1
	GXNU20220605	5.0	8.5	4.9	7.2	1.9	6.0	1.7	7.3	3.7	4.6	5.3	3.8	3.2	4.0	0.9
	GXNU20220606	3.7	7.1	4.2	6.8	1.4	4.9	1.4	5.8	2.8	3.9	4.9	2.3	2.8	3.4	0.8
	GXNU20220607	4.3	6.6	3.9	6.2	1.6	4.7	1.1	6.1	2.5	4.1	4.6	2.7	2.8	3.2	0.7
	GXNU20220608	4.4	6.8	3.9	6.7	1.7	4.6	1.2	6.4	3.2	4.0	5.5	2.4	3.2	3.5	0.9
	GXNU20220609	3.9	7.1	3.8	6.5	1.6	4.9	1.5	6.8	3.1	4.7	5.8	3.8	2.9	3.0	0.8
	GXNU20220610	4.1	6.8	3.3	6.0	1.2	4.7	1.1	5.6	2.5	4.0	4.2	2.8	2.5	2.9	0.9
O. guananensis	KIZ2010003067	7.2	12.7	6.8	11.6	2.8	8.8	3.0	10.5	5.3	9.1	11.3	7.8	5.1	5.7	1.4
	KIZ2010003068	6.9	11.0	6.0	10.5	2.3	8.0	2.2	9.5	4.5	7.6	9.8	5.9	4.8	5.0	1.8
	KIZ2010003069	6.1	10.0	5.4	8.9	2.1	7.6	1.9	8.5	4.0	7.6	8.8	6.3	4.3	4.7	1.2
	KIZ2010003070	5.7	9.7	5.8	8.6	2.3	6.7	1.7	7.6	3.6	6.9	7.9	5.0	4.1	4.8	1.6
	KIZ2010003071	5.5	9.5	5.6	8.7	1.7	6.3	2.1	8.2	3.8	5.9	7.4	3.4	4.1	4.5	0.9
	KIZ2010003072	8.1	12.7	7.0	10.5	3.2	10.1	2.2	10.5	4.8	9.2	11.8	6.8	5.9	6.2	1.8
O. guilinensis	ASIZB208001	38.3	12.2	6.8	10.7	2.7	9.0	2.2	10.9	4.3	7.1	7.4	4.6	5.7	6.0	1.9
	ASIZB208002	12.6	12.8	5.9	10.5	2.9	8.4	2.3	10.1	5.1	6.9	7.4	5.2	4.1	4.8	1.5
	ASIZB208003	35.4	11.6	6.3	10.9	3.1	8.3	2.2	9.8	4.8	8.2	6.7	4.4	5.1	5.6	1.7
	ASIZB208004	52.3	12.0	4.8	10.3	2.1	7.3	2.3	9.8	4.2	6.0	7.7	5.1	4.8	5.0	1.7
	ASIZB208005	48.6	11.5	5.5	9.6	2.9	7.9	2.2	9.7	4.6	6.4	5.9	4.5	4.9	5.1	1.4
	ASIZB208006	7.6	8.7	5.4	8.0	2.0	6.3	1.8	8.1	3.8	4.7	5.3	4.4	3.8	4.5	1.3
	ASIZB208007	6.4	11.4	5.6	10.5	2.2	7.2	1.7	8.8	4.5	6.1	7.6	4.6	4.1	4.9	1.0

Species	Voucher number	CPD	DFL	DFBL	PFL	PFBL	VFL	VFBL	AFL	AFBL	MBL	OSBL	ISBL	DAN	DPN	DAPN
O. luochengensis	KIZ2010003073	8.6	13.0	7.5	10.9	2.9	8.5	2.2	11.4	5.0	6.1	7.3	4.4	5.0	5.6	1.4
	KIZ2010003074	6.6	12.7	6.7	11.7	2.8	9.0	2.3	10.9	4.4	6.7	7.7	4.5	4.9	5.3	1.3
	KIZ2010003075	7.5	13.2	6.9	12.7	3.1	10.1	2.4	11.6	4.9	8.5	9.3	6.2	5.2	5.8	1.2
	KIZ2010003076	7.5	12.3	6.8	11.9	2.9	9.3	2.3	10.9	5.1	7.2	8.3	4.6	5.0	5.4	1.5
	KIZ2010003077	7.1	11.4	6.3	10.8	3.0	8.2	1.9	9.6	4.6	7.5	9.4	5.6	5.0	5.2	2.0
	KIZ2010003242	6.8	12.7	6.6	11.6	3.0	9.8	2.7	10.5	5.0	6.4	6.7	4.8	4.9	5.4	1.3
	KIZ2010003243	8.7	12.6	7.3	12.0	3.6	9.3	2.4	10.5	4.9	7.2	7.4	4.8	5.2	6.0	2.1
	KIZ2010003244	6.0	11.3	6.0	11.3	3.4	8.6	2.0	9.6	4.2	6.4	6.6	5.1	4.7	5.0	1.4
O. platycephalus	KIZ2003007105	8.9	13.6	6.8	12.9	3.5	11.5	2.7	12.1	4.9	9.2	10.9	6.3	5.7	6.2	1.8
	KIZ2003007106	7.9	12.0	6.4	11.5	2.5	9.7	2.1	10.5	5.2	6.9	8.2	5.3	4.9	5.1	1.6
	KIZ2003007110	7.5	9.5	6.0	9.4	2.5	8.8	2.2	8.8	4.6	6.5	7.0	4.2	4.0	4.9	1.5
	KIZ2005006211	5.8	8.5	4.1	8.5	1.9	7.6	1.6	8.2	3.7	5.4	5.5	4.2	4.0	4.3	1.2
	KIZ2005006212	5.7	8.0	4.3	8.5	2.0	7.2	1.8	7.4	3.5	4.6	5.6	3.4	3.0	3.4	0.9
	KIZ2005006214	5.8	9.5	4.6	9.1	1.8	7.7	1.8	8.4	3.7	4.8	4.9	4.1	3.9	4.1	1.1
	KIZ2005006215	6.1	9.4	4.6	9.1	2.3	8.0	2.0	8.8	3.7	4.7	6.1	3.9	4.0	4.6	1.3
	KIZ2005006216	5.5	8.8	4.5	9.3	2.1	8.0	1.8	8.2	3.8	3.8	5.8	3.7	3.2	4.0	1.0
O. polystigmus	KIZ2001004626	7.3	10.1	6.0	8.3	2.0	7.0	1.7	8.6	4.3	6.5	7.9	4.7	4.8	5.4	1.1
	KIZ2001004627	5.8	8.9	4.8	7.1	2.0	6.3	1.6	8.1	3.9	6.4	5.4	3.5	3.4	4.4	1.0
O. polystigmus	KIZ2001004628	3.2	6.8	3.7	6.2	1.6	5.9	1.4	6.1	4.1	3.0	4.6	3.2	2.7	3.3	1.1
	KIZ2001004629	4.2	7.5	4.2	7.0	1.8	5.2	1.1	6.8	3.6	4.9	5.5	3.1	2.9	3.3	1.2
	KIZ2001004630	3.9	6.7	3.6	5.3	1.5	4.9	1.0	5.0	2.6	2.9	4.6	1.7	2.7	3.2	0.7
	KIZ2001004631	4.3	6.1	3.2	5.2	1.5	4.5	1.4	5.4	2.6	3.5	4.9	2.7	2.3	3.0	1.1
	KIZ2001004632	3.8	7.1	3.6	5.6	1.1	5.9	1.1	6.9	3.9	3.7	3.8	2.4	2.8	3.5	0.9
	KIZ2001004633	5.0	8.1	4.0	8.0	1.7	5.9	1.2	7.5	3.3	5.0	6.1	4.7	3.0	3.5	1.0
	KIZ2001004634	4.3	7.8	5.4	7.0	1.9	6.0	1.6	7.4	4.0	5.9	5.8	4.1	3.0	3.6	1.1